Final Project Report to the NYS IPM Program, Agricultural IPM 2002-2003

Title: Implementing Soil Health Monitoring on Vegetable Farms in New York State

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Vegetable farmers in participating counties

Type of grant:
Cultural methods.

Project locations:
Columbia, Erie, Oneida, Onondaga, Oswego, Suffolk, Wayne and Yates counties.

Abstract:
The long-term viability of the vegetable industry in NYS is dependent on the health of its soils. Good soil stewardship requires knowledge about a wide range of soil health issues and the practices that affect them. To improve their soil management capabilities, farmers, agribusiness professionals and extension educators need better tools for monitoring the physical, chemical and biological health of soils. They also need training in the use of these tools, and in the interpretation of results from soil health monitoring activities. Those who manage soils also need more information about the impact of specific practices on soil health. The leadership of this project is comprised of members of the Soil Health PWT. We will develop a soil health monitoring protocol and demonstrate its use to extension educators and farmers in five pilot regions in the state. We will also assess the soil health status of several indicator farms in each of these regions.

Background and Justification:
When soil health on a vegetable farm declines, the productive life and economic viability of the farm also declines. An adequate survey of the health status of New York's vegetable soils does not exist. Nor does a protocol exist for undertaking such a survey. Undoubtedly, numerous vegetable soils in the state are the beneficiaries of tillage practices, crop rotations, cover cropping, fertilizer programs and other practices that result in good soil health, but many other soils suffer from compaction, erosion, diminished levels of organic matter and biological activity, persistent weeds, soil-borne pathogens, nutrient imbalances and other soil illnesses. Information regarding the health of the state's soils would be useful in increasing vegetable farm productivity and in directing relevant research and extension activities.

To manage soils well, farmers need to know how to assess the soil health status of their soils over time. To do this, they need a comprehensive set of monitoring tools and clear guidance in how to use them. This set of tools and associated protocols should include several measurements of the structural, chemical and biological health of the soil. Farmers will need training in interpreting the results of their soil monitoring activities. And farmers will need more information about the impact of specific practices on soil health, and guidance in devising strategies that will effectively address shortcomings in their on-going soil management plans.

Objectives:

1. To establish protocol for monitoring the (physical, chemical and biological) health of soils used in vegetable production.
2. To demonstrate soil health monitoring protocol to extension educators, agribusiness professionals and farmers.
3. To establish the soil health status of several indicator farms in NYS.
4. To demonstrate how selected farming practices impact soil health.

Procedures:

1. A subcommittee of the Soil Health PWT (consisting of Cornell faculty, extension educators and farmers) will establish soil health monitoring protocol. The protocol will include key measurements of the physical, chemical and biological status of soils. The protocol will be comprised of a combination of laboratory assays, in-field measurements and observations.

2. The soil health monitoring protocol established by the Soil Health PWT will be demonstrated at five pilot locations in the state. The five participating extension educators will each assemble teams of farmers, agribusiness professionals and Cornell faculty who will meet at a farm to undergo training in how to assess the health of a farm's soils. The in-field measurements, observations and sampling techniques called for in the protocol will be demonstrated.

3. The five regional teams will use the protocol to establish the soil health status of several indicator farms in their localities. The results of these soil health analyses will be used to help direct the future research and extension activities of the Soil Health PWT and serve as the beginning of a base-line survey of the soil health status of New York's vegetable farms.

4. In each region, the impact of selected practices on soil health will be assessed using paired comparisons.

Results and discussion:

1. Columbia County – Ted Blomgren

During the 2002 growing season, soil health monitoring demonstrations took place at a commercial farm in Claverack, NY and at the Cornell research farm in Valatie, NY. We performed chemical, biological and physical assays at both sites. At the Claverack site, the growers who hosted the demonstration were interested in how they might discern any benefits from integrating a red clover and grass cover crop into their vegetable rotation on a moderately heavy Occum loam soil. The three fields we studied at the Claverack site were: 1) continuous vegetables (with additions of compost), 2) first-year vegetables following two years of red clover and mixed grasses, and, 3) a third-year clover/grass cover crop (with vegetables scheduled for the 2003 season).

Soil samples were sent to the Cornell Nutrient Analysis Laboratories for chemical analysis. Biological health monitoring was focused on assessments of crop (lettuce) health, weed populations, cation exchange capacity, and organic matter levels. Physical health was measured using a penetrometer and an infiltrometer - an instrument that measures water infiltration during simulated rainfall. We also measured bulk density and identified the soil series in the Columbia County soil survey.

The chemical analysis showed most nutrients to be in the medium range. The compost applications in the continuous vegetable field gave it the highest phosphorus value. Cation levels corresponded to pH values, with the field in its first year of vegetables following the clover/grass rotation having the highest pH, and the field currently in clover and grass having the lowest pH. Although nutrients were not particularly high, they were in an acceptable range.

The health of the lettuce crop was very good in all fields (with the exception of some plants infected with viruses) indicating that the crop's nutrient needs had been met relatively well. Organic matter was similar in the two vegetable fields, but the field in the clover/grass mix had a slightly higher level. Exchange acidity, too, was

slightly higher in the clover/grass field, probably because of the elevated number of exchange sites on the organic material.

The high clay content of the Occum soils at the Claverack farm makes them particularly susceptible to compaction. Use of a penetrometer indicated that some sites were indeed compacted, but no conclusions could be drawn across systems. The field growing vegetables following two years of the clover and grass mix showed a high rainfall infiltration rate (50 min. to runoff), but it was only slightly higher than the field growing continuous vegetables (40 min. to runoff). To our surprise, the field in which the clover/grass mix was currently growing showed a much lower water infiltration rate (10 min. to runoff). We concluded that the soils had likely become compacted while mowing in wet conditions.

The farmers in Claverack learned how to use several new tools for monitoring the health of their soils. In addition, they have begun to see some measurable benefits related to a cover crop-intensive rotation, including increases in organic matter and exchange capacity. They have begun to see evidence that this rotation might enable them to get away from expensive applications of compost, although they have questions regarding the economic viability of such a rotation. And they have become more aware of how use of a tractor to mow a cover crop might result in compaction if soils are wet. We agreed that in future years we would experiment with some additional tests measuring biological activity, including the Bait Lamina test, assays for soil respiration and pathogenic nematodes, and a laboratory test for easily mineralizable nitrogen.

The Valatie site consisted of an old sod growing on a light-textured Hoosic gravelly loam that had been converted for vegetable production. This field was the site of the first-year plots of an IPM-funded Cucurbit Systems Study. We were interested in documenting the changes that would take place during the conversion from a sod field to one in which tillage would take place annually. The field was divided into two portions – one that was plowed and rotovated in preparation for vegetables, and one that was left in sod. Soil monitoring was undertaken in both portions. The kinds of monitoring activities at the Valatie site were similar to those previously described.

These plots were shown to growers as part of an open house at the Valatie Farm in the fall. The chemical analysis showed most nutrients to be in the low to medium range. The 600 lb organic fertilizer application (Fertrell 5-4-3) made to the tilled portion of the field was not much in evidence by the end of the season. The zucchini and cucumber crops grown in the tilled portion of the field were very healthy, and yields ranged from average, in the low-input treatments, to very high, in the plasticulture treatments. Organic matter was lower in the tilled portion, probably because organic matter was oxidized more rapidly where tillage aerated the soil. Soil pH and phosphorus, too, were slightly reduced in the tilled portion. Little compaction was in evidence in this field. Soils were rather wet when they were subjected to infiltrometer measurements and, consequently, showed a similarly low capacity to absorb water before horizontal runoff (6 and 9 min. to runoff for the tilled portion and the sod, respectively). Soil monitoring will be continued for the 3-year duration of the trial.

2. Onondaga and Oswego Counties – Jan van der Heide

During the 2002 growing season, I have purchased a penetrometer and demonstrated its use on 7 muck vegetable farms. The physical soil characteristic that appears to limit production of vegetable crops on muck soils most severely is soil compaction. A distinct compaction layer can be detected on fields were drainage is impaired, and where plant performance is reduced during the growing season.

These compaction layers are often only a few inches thick, and can consistently be found directly below the plow layer. In a comparison between fields with good yields and fields with average or below average yield, the presence of a compaction layer correlates very well with disappointing yields. Similarly, fields where no distinct compaction layer can be found produce crops of onions with above average yields.

Several growers have grown summer cover crops of Sorghum Sudan grass or pumpkins in the 2002 growing season on fields where poor historical onion yields and inadequate drainage have prevented the profitable

cultivation of a high value crop, like onions. We have made plans to assess the effect of these cover crops on the compaction layer and the ability of cover crop plant roots to penetrate and break up this impediment to good production.

Similarly, the demonstration of the presence of compaction layers has prompted growers to fall plow their fields at a greater depth in an attempt to break up the compaction layer. For those growers that rely on spring tillage, the penetrometer readings will be useful in determining the proper depth of the tines on the chisel plows.

Soil Health education efforts for upland vegetable growers in Onondaga County have focussed on soil water holding capacity and the adaptation of the use of cover crops, composts and manures to improve soil productivity. To this end, I organized a twilight meeting on July 24 and invited Bob Schindelbeck to demonstrate the use of the infiltrometer as a Soil Health management tool. The soils in most of the Onondaga County vegetable production areas range from a gravely sand to a sandy loam with low to very low water holding capacity. In addition, some of the finer soils have problems with soil compaction and impeded drainage.

A demonstration of the importance of soil organic matter showed the impact of heavy rainfall on the soil structure in the absence and presence of adequate soil organic matter. Strategies for the improvement of soil organic matter and cultural practices that minimize the destructive impacts on soil structure were discussed. All attendees (15) received a copy of the book "Building Soils for Better Crops".

We are preparing collaborative projects with some Onondaga County vegetable growers to enhance water holding capacity and productivity of the lighter soils in the Baldwinsville and Kirkville area.

3. Wayne and Yates Counties – Carol MacNeil

PROTOCOL FOR MONITORING THE HEALTH OF SOILS

Discussion on soil health indicators and what tests to do occurred at an open meeting of the Cornell Program Work Team on Soil Health – Vegetables, which occurred on February 12th during the 2002 NYS Vegetable Conference in Syracuse. About 35 people, half of who were interested growers, attended the meeting. Some or all of the following tests were done on soils in fields tested statewide in 2002.

Physical characteristics – water infiltration rate, soil compaction, bulk density
Chemical characteristics – nutrient levels as measured by the Cornell complete soil test
Biological characteristics - % organic matter, rooting depth, pathogenic and total nematodes (George Abawi, Plant Pathology, Cornell), and subjective soil/crop health indicators

DEMONSTRATING THE SOIL HEALTH MONITORING PROTOCOL

A meeting was held at the NYS Agricultural Experiment Station research farm on August 20, 2002 to train extension educators and farmers how to do the tests listed above. Twenty people attended, including 3 growers (photo included). The training site was IPM Vegetable Coordinator Curt Petzoldt's and Jim Engel's Vegetable Systems Trial, 1995 – 2002.

Curt presented soils information comparing conventional, organic, IPM present and IPM future over the life of the trial. The soil tests included: % organic matter; pH; nutrient levels; and nitrates during the season. Curt also presented information on new biological activity tests including the Bait-Lamina Test and the use of BIOLOG GN plates. (The easily mineralizable nitrate test was suggested earlier by Laura Drinkwater, Horticulture, Cornell, as a good measure of active organic matter.)

George Abawi, Plant Pathology, Cornell, presented data comparing total nematodes/100 cc of soil for the four systems. Total nematode levels are a good measure of total biological activity. The conventional plot had the lowest count (480), especially compared to the organic plot (1210). George also distributed the procedure for sampling soils and conducting a bioassay for nematodes and other plant pathogens.

Bob Schindelbeck, Crop and Soil Science, Cornell, demonstrated how to use the Cornell water infiltrometer (photo included) and the DICKEY-john penetrometer for measuring compaction. Bob distributed the following equipment to extension and NEON staff: infiltrometers, penetrometers and bulk density rings.

ESTABLISHING THE SOIL HEALTH STATUS ON INDICATOR FARMS – WAYNE AND YATES COUNTIES

We did intensive sampling late in the season of four onion fields (all very high organic matter, deep, Carlisle muck) on two farms. Fields of onions grown after 3 - 5 years of onions were compared with fields of onions grown after one year of sudangrass or soybeans. All fields were irrigated. Water infiltration rate (3 spots/field), compaction (10 spots/field) and rooting depth (4 spots/field) were compared, and samples were taken for a complete Cornell soil test and for total and pathogenic nematode analysis (5 spots/field). In both comparisons adding the sudan or soybeans to the onion rotation increased the rooting depth, increased the water infiltration rate and decreased the compaction. The growers also report that weed pressure is down after soybeans or sudan, compared to onions after onions. Pathogenic nematodes were higher, and beneficial nematodes were lower, in the onion after onion fields compared to onions after soybeans or sudan.

We also sampled two organic vegetable fields on one farm. Crops were on black plastic in both cases. Transplanted onions were in new permanent beds in a field that was in grasses for 20 years followed by rye and oat cover crops on a Madrid gravelly fine sandy loam. The onions were occasionally trickle irrigated. Bulb size was good considering the dry season. Snap beans were in permanent beds established four years ago in a strip that was carrots the previous year with a rye cover crop in between on a Palmyra gravelly loam. Bean growth was lush. A complete Cornell soil test was done as well as tests for total nematodes (6 spots/field) and compaction (few spots). Compaction tests indicate that the soil was very loose down to the depth of tillage in both fields. The soil to the tillage depth, where the beans were planted, in four year old permanent beds, was extremely loose and friable and had a dark color and rich smell. Because the soils were dry the compaction numbers can't be compared to our results for fields in 2001. Nematode levels are still being measured.

DEMONSTRATING HOW FARMING PRACTICES IMPACT SOIL HEALTH

A soil health field stop was organized for the NEON Organic Field Day held August 14, 2002 at the Klaas and Mary-Howell Martens Farm near Penn Yan. About 100 organic and conventional growers attended. Mary-Howell described cropping and soil management on their farm. Bob Schindelbeck, Cornell, demonstrated the stability of a soil in a rotation with soil-building crops compared to a heavily row-cropped soil by simulating rainfall with the Cornell infiltrometer. Run-off from the "good" soil was clear while that from the heavily cropped soil was muddy. Carol MacNeil demonstrated how to use the DICKEY-john penetrometer to check for compaction and about 20 growers gave it a try.

An open meeting of the Cornell Program Work Team on Soil Health – Vegetables has been planned for February 11th at the 2003 NYS Vegetable Conference in Syracuse. Research/survey results from 2002 will be presented there as well as being included in extension newsletters. There will be a roundtable discussion so growers have an opportunity to express their concerns and share what they're doing about soil health.